Electronic Supplementary Information

Highly Durable Fuel Cell Electrode Based on Ionomer Dispersed in Glycerol

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1. Stress-strain behavior of Nafion membranes cast from three dispersions.

The stress-strain behavior of Nafion membranes cast from three dispersions was measured by a mechanical thermal analyzer (TA Instruments Q800-RH). In order to remove the thermal history of the membranes, all membranes were dried at 140°C. The temperature and humidity were controlled in a humidity control chamber. The tensile tests were performed using ten 30 mm rectangular test strips at a load ramp of 0.5 MPa min^{-1} at 50°C, 50% RH. The stress-strain behavior of the membranes was measured after obtaining equilibrium RH at least for 60 min. At least 3 samples were tested. Table S1 shows the stress, modulus, strain and tensile fracture energy. Tensile fracture energy was calculated by integration of the stress-strain area.

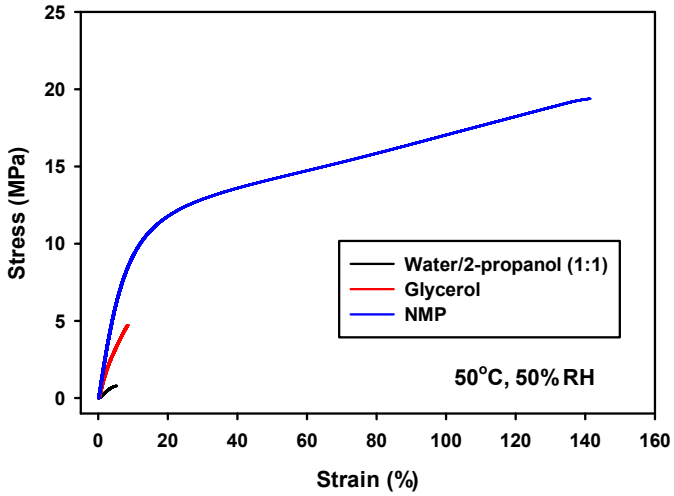

Fig. S1 Stress-strain curves of Nafion membranes cast from water/2-propanol, NMP and glycerol dispersions.

Table S1 Tensile properties of cast Nafion

Dispersing solvent	Maximum Stress (MPa)	Modulus (MPa)	Maximum Strain (%)	Fracture Energy (Mpa)
Water/2-propanol	0.8 ± 0.04	137 ± 44	5.1 ± 1.4	0.02 ± 0.006
Glycerol	4.2 ± 0.7	88 ± 8	7.0 ± 0.9	0.18 ± 1.1
NMP	17.4 ± 2.8	121 ± 16	126 ± 13	17.5 ± 4.8

2. Time-dependent relaxation behavior of cast membranes prepared from water/2-propanol, NMP, and 1,2 propanediol

The morphology of cast Nafion membranes characterized by atomic force microscopy (AFM). Membranes cast from three dispersions were dried at 140°C for 6 h and then exposed to saturated water vapor at 100°C for 1 and 3 h (or room temperature 50% RH for 6 month and additional 100°C for 2 h for the membrane from glycerol). AFM images were obtained at ambient conditions after drying the sample at 60°C for 30 min. A Veeco Metrology D3000 microscope with a Nanoscope IIIa controller with standard commercially available SFM 125 micron long silicon cantilevers with a spring constant of about 40 N/m was used to obtain all images. Identical operating conditions, i.e. cantilever drive amplitude and set point, and same tip were employed for each sample.

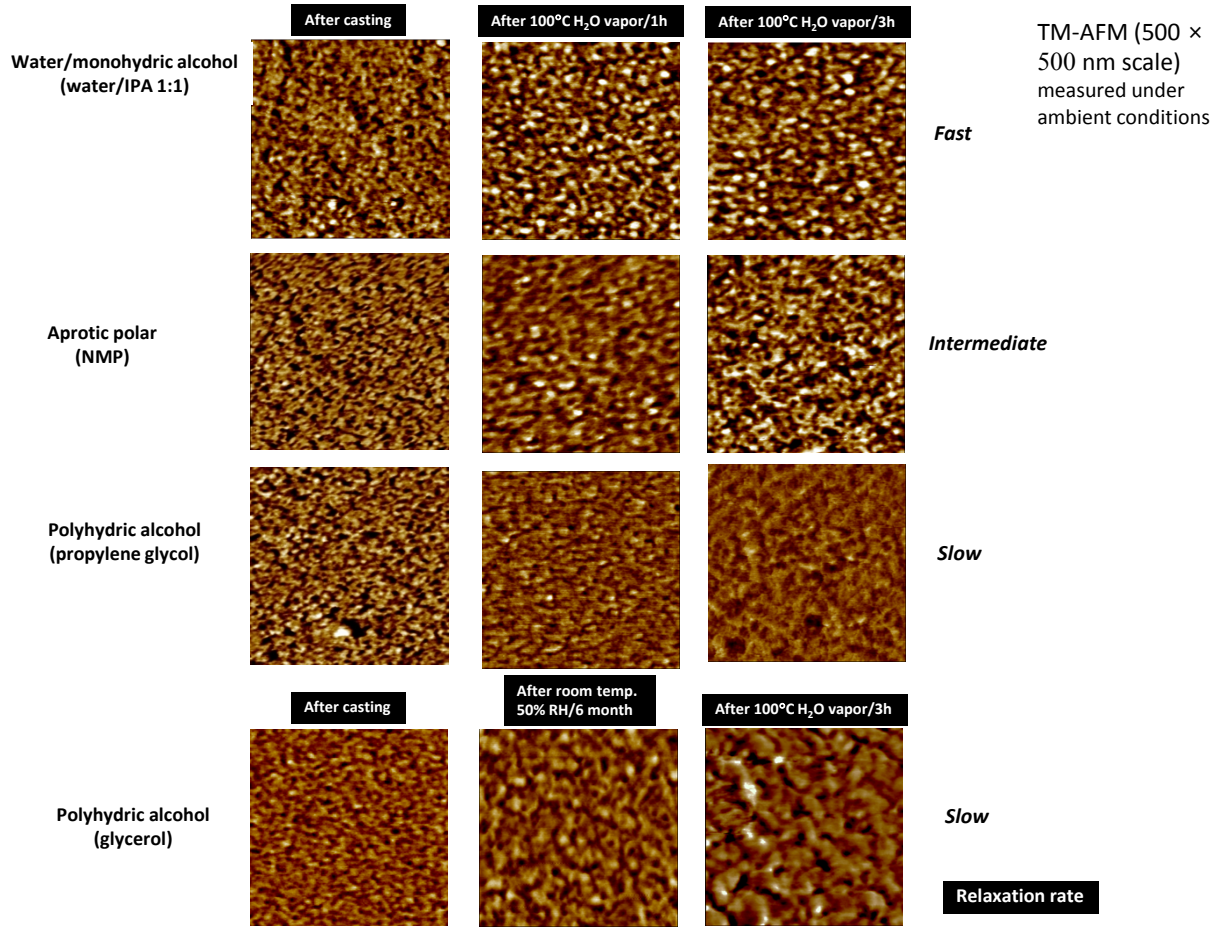

Fig. S2 Morphology change of Nafion after exposure to water vapor. The difference in color from bright to dark indicates differences in height, with bright being higher than dark.

3. Fuel cell polarization plots of a commercially available MEA after potential cycling.

The polarization curves obtained before cycling (red) and after 10K (pink), 30K (green) and 70K (blue) of potential cycles from 0.6 to 1.0 V under nitrogen conditions. Membrane: reinforced PFSA (25 mm thick); Catalyst: 40% Pt on carbon; Catalyst loading: 0.4 mg/cm^2; Active area: 25 cm^2

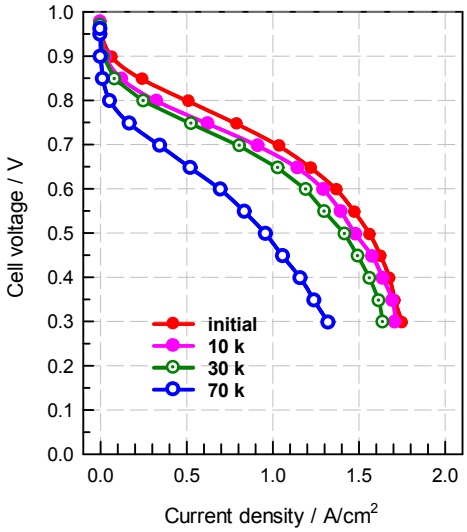

Fig. S3 Fuel cell polarization plots of commercially available MEA after potential cycling test. The polarization curves obtained before cycling (red) and after 10K (pink), 30K (green) and 70K (blue) of potential cycles from 0.6 to 1.0 V under nitrogen conditions.

4. Pt particle size and spatial distribution

Pt particle size analysis obtained from TEM images.

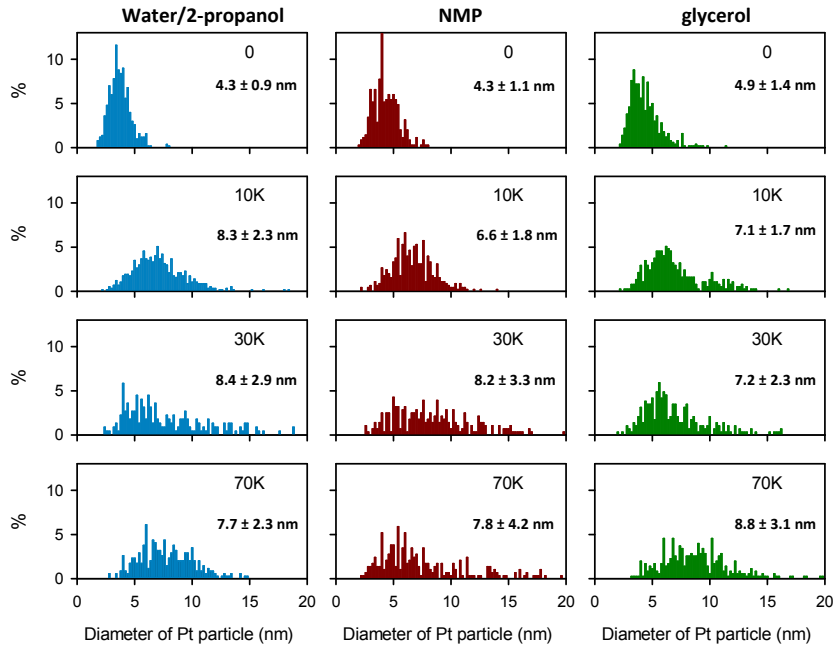

Fig. S4 Pt particle size and distribution obtained from TEM images after potential cycling test. Numbers in the graphs are the average and standard deviation.

5. TEM images of fuel cell cathodes after potential cycling test.

MEA samples were prepared for TEM analysis by embedding in epoxy (Araldite 6005, SPI Supplies) and then sectioning on a Leica Ultra Microtome. The ~50nm thick sections were transferred to Cu TEM grids and then examined on a Hitachi HF3300 operating at 300kV. The samples were imaged at several positions across the cathode starting at the membrane and then proceeding out towards the gas diffusion layer.

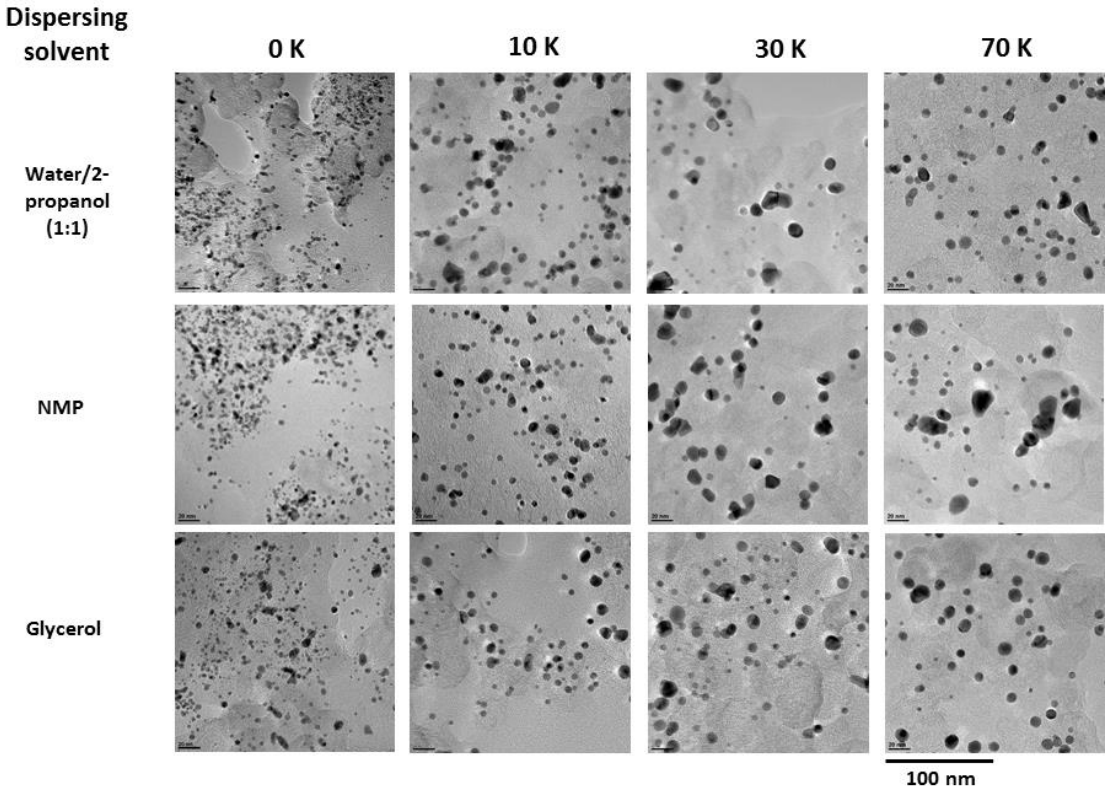

Fig. S5 TEM images of cathodes prepared from three dispersions. Images were taken from the middle of the electrodes before and after potential cycling test.

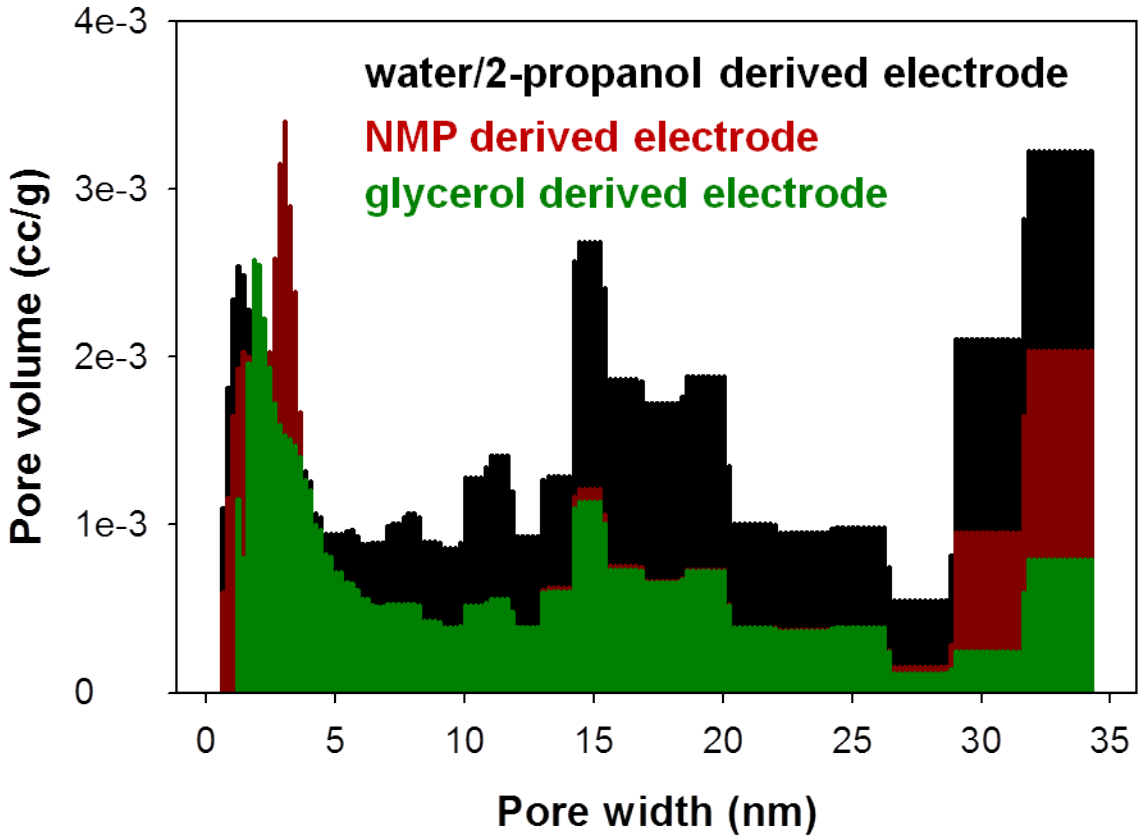

Fig. S6. Pore volume and pore size distribution of water/2-propanol, NMP, and glycerol derived electrodes as measured by N_2 adsorption isotherms using a Quantachrome Autosorb iQ .